No. XXV.

Description and Use of a Simple Appendage to the Reflecting Sector, by which it is rendered capable of measuring all possible Altitudes, on Land, by Reflection from an Artificial Horizon. By Robert Patterson.—Read, September 19, 1817.

SINCE the discovery of the reflecting sector, various attempts have been made to extend the limits of its capacity in measuring angles. This becomes especially necessary in taking altitudes on land, by means of an artificial horizon, or reflecting horizontal surface; since, in this case, the altitude measured is, from the construction of the instrument, but *one half* of that pointed out by the index on the limb: thus, an octant will not measure an altitude of more than 45°, a sextant, not one of more than 60°, a quintant, not one of more than 72°; and beyond this, the limits of the sector has seldom if ever, been extended. It is, indeed, perfectly obvious, that no instrument of this kind can, by means of a reflecting horizontal surface, measure an altitude of 90°; for, then, the incident ray and the reflected ray must coincide, and both pass through the eye of the observer—which is evidently impossible. Nay, when the altitude exceeds 75°, the head of the observer will, almost unavoidably, intercept the incident ray, in its passage to the reflecting surface. Besides, the field of

view, from the obliquity of the index speculum, will then become too much contracted to afford an easy observation.

No improvement, therefore, in the construction of this instrument, can ever be expected to answer the purpose of measuring all possible altitudes by means of a common artificial horizon: but with the aid of the following very simple appendage, this purpose will be completely answered, even by the common octant.

The whole apparatus, to be used with the reflecting sector, consists of three parts.

1. An artificial horizon, or horizontal reflecting glass plane, with its adjusting screws.
2. A spirit-level.
3. A reflecting inclined plane.

The two first parts of this apparatus, as well as the manner of adjusting them, are well known, and, therefore, need not here be described.

Plate IX. fig. 4, represents a side view of the reflecting inclined plane, nearly of its natural size. It is composed of

1. A triangular frame of cast brass A B C. The thickness of the frame is about 1-4th of an inch, its breadth about 1 3-10ths, and the lengths of the sides A B, B C, each about 2 inches: so that the bases A B, B C, may be nearly of the same dimensions with the face of the index speculum of a reflecting sector.

2. A plate of ground glass, cemented on the plane A C with black sealing-wax, or any other black cement, the polish being previously taken off the lower surface, to prevent a double image:—*a c* represents the edge of this glass. The inclination of the reflecting surface *a c* to the base A B, [angle A] should be made about 35°, and to the base A C, [angle C] about 45°. The quantity of these angles must, however, be accurately determined; and this may be done by either of the following methods.

METHOD FIRST.

1. Make a reflecting sector [octant or sextant] fast in a vice, or in any other convenient way, with its plane perpendicular to the horizon, and the speculum of the index, when this points to *o* on the limb, nearly horizontally.

2. Lay a thin, flat piece of board, metal, or glass, on the face or frame of the index speculum, and on this place the spirit-level, extending in the direction of the index; then gently move the index up or down the graduated limb, till the air-bubble of the spirit-level settles under the central mark on the tube; and note the degree, minute, and part, to which the index then points.

3. Under the spirit-level introduce the reflecting inclined plane, resting on its base A B, and its angle A pointing to the limb of the instrument.

4. Move the index up the limb, till the air-bubble of the spirit-level again settles under the central mark on the tube; noting, as before, the degree, minute, and part, to which the index now points.

5. Take the difference between this arch and that to which the index pointed when horizontal, if both on the same side of the *o*, but their sum, if on opposite sides; and the *half* of this sum or difference will be the quantity of the angle A. In a similar manner, laying the inclined plane on its base B C, may be found the quantity of the angle C.

In this way, by repeated trials, and taking a mean, you may, with a sensible spirit-level, find the angles of the inclined plane with great accuracy; and these angles, it is evident, can never afterwards be subject to any variation.

The above method was suggested to me by Mr. F. R. Hassler, some years ago, when preparing an apparatus of this kind for Mr. Jefferson.

METHOD SECOND.

1. Let the index error of your reflecting sector be ascertained, by measuring the apparent diameter of the sun on each side of the *o*, and taking a mean, as it is commonly done.

2. Place the inclined plane with its base A B on the face of the index speculum, the angle A pointing to the limb of the instrument, and, in this position, make it fast to the speculum, by means of a *spring-clamp* of wire, sheet brass, or the like.

3. With your eye at the eye-hole, or telescope of the instrument, defended by a shade or coloured glass, look through the transparent part of the horizon-glass, directly at the body of the sun, and, moving forward the index, proceed as in finding the index error ;* noting the degree, minute, and part, on the limb to which the index points, at the apparent coincidence of centers; then, this arch, allowing for the index error, previously found, will be *double* the angle A of the inclined plane.

4. In a similar manner, by placing the inclined plane with its base B C on the index speculum, and angle C pointing to the limb of the instrument, you may find the quantity of the angle C.

Instead of the sun, you may make use of any well-defined, illuminated, object on land; as the top of a chimney, the ridge of the roof a house, or the like; in which case, no shade will be necessary to defend the eye, and the mean of a number of observations will perhaps be equally accurate with that obtained from an observation of the sun.†

* If the reflected image of the sun should appear *at one side* of that seen by direct vision, then, by giving the inclined plane a small angular motion on its base, you may adjust this side-error by bringing the two images into apparent coincidence.

† If a light shade be placed behind the horizon-glass, then, the image of a terrestrial object, if moderately illuminated, will be seen by reflection from

Directions for the use of the above apparatus, in measuring all possible altitudes of the sun, by means of a reflecting sector.

The sector being adjusted, or its index error ascertained; the artificial horizon placed in the sun, and, by means of the spirit-level and adjusting screws, brought to a true level in all directions—then

CASE I.

When the altitude is not less than 10°,* and does not exceed the limits of the instrument, viz. 45° for the octant, and 60° for the sextant, it may be found, in the usual way, by reflection from the artificial horizon.

CASE II.

When the altitude is less than 10°.

1. On the artificial horizon, place the reflecting inclined plane on its base A B, with its angle A directly towards the sun.

2. Measure the altitude above the plane A C; and then from this altitude *subtracting* the angle A of the plane, the remainder will be the altitude above the horizon.

In this position of the plane, any *depression* of an object not more than 25° below the horizon, and, by the octant, any altitude not exceeding 10°, or, by the sextant, not exceeding 25°, may be measured.

the transparent part of the horizon-glass, and thus the apparent coincidence or contact will be more accurately observed.

* When the sun is less than 10 deg. above the reflecting plane, the field of view will be too much contracted; but this circumstance, by the above apparatus, may always be avoided.

CASE III.

When the altitude exceeds the limits of the instrument.

1. On the artificial horizon, place the inclined plane on its base A B, with its angle A directly opposite to the sun.

2. Measure the altitude above the plane A C, and then to this altitude *adding* the angle A of the plane, the sum will be the altitude above the horizon.

In this position of the plane, any altitude from 45° to 80°, may be measured by the octant, and any altitude whatever above 45°, by the sextant.

CASE IV.

When the altitude exceeds 80°, and the octant is used.

1. On the artificial horizon, place the inclined plane on its base B C, with its angle C directly opposite to the sun.

2. Measure the altitude above the plane A C, and then to this altitude adding the angle C of the plane, the sum will be the altitude above the horizon.

REMARKS.

I. The sun's image reflected from the artificial horizon, when not silvered, will appear nearly of the same degree of brightness with that, after two reflections, from the specula of the instrument—a circumstance of some importance in making accurate observations.

II. In taking a meridian altitude of the sun, it will be necessary to turn round the reflecting inclined plane, (when this is used) according to the change of sun's azimuth, so that the end farthest from the observer may point directly towards the sun. If the inclined plane be turned gently backwards and

forwards with one hand, (the instrument being held by the other) while making the observation, then, the two images of the sun will appear alternately to recede from and approach each other, and thus the apparent contact of the limbs will be accurately observed as they pass each other.

III. By means of this inclined plane, the common octant may have its range extended to that of the sextant, or even to that of the quintant, thus—Attach this inclined plane to the index speculum resting on its base A B, with the angle A upwards; then, the reflecting surface of the inclined plane may be considered as the index speculum; and, with this, any angle or altitude, measured in the usual way, will be equal to *that* pointed out by the index on the limb, *increased* by the quantity of the angle A of the inclined plane.

IV. By the aid of this inclined plane, the horizon glass of the octant for the back observation, may be very accurately adjusted, or the index error ascertained thus:—

1. Attach the inclined plane, by means of the spring-clamp, with its base B C resting on the back part of the index speculum frame, and the angle C downwards.

2. Move forward the index on the limb till it points to *double the complement* of the angle C of the inclined plane.

3. With your eye at the eye-hole, look through the transparent part of the back horizon glass, directly at the sun, and moving the lever of this glass, bring the reflected image to coincide with that seen by direct vision—and then this glass is adjusted. Any small error of adjustment may be found afterwards, by taking a mean of the two contacts of limbs, as in adjusting for the fore observation.

Any error in the parallelism of the face of the index speculum, to the back part of its frame, may be very accurately ascertained thus:—

1. Make the sector fast in a vice, &c. as directed in the first method of finding the angles of the inclined plane.

2. Lay a piece of index speculum glass on the face of the index speculum, and on this place the spirit-level, in the direction of the index.

3. By moving the index, bring the air-bubble to settle under the central mark on the tube, and note the degree, minute, and part, to which the index then points.

4. Place the same piece of glass, or any other plane surface, on the back part of the speculum frame, projecting a little beyond its outer edge.

5. On this projecting part place the spirit-level, touching the edge of the frame, and, moving the index, if necessary, bring the air-bubble again to settle under the central mark on the tube, noting, as before, the degree, minute, and part, to which the index now points; then *half the difference* between this and the former arch will be the error in the parallelism of the face and back part of the index speculum; for which proper allowance must be made in the above adjustment of the back horizon glass.

V. The altitude of the moon, or of a bright star, or of any terrestrial object, sufficiently illuminated, may, it is obvious, be taken in the same manner as that of the sun. In this case, however, if the reflecting inclined plane were of silvered glass, the observation might, no doubt, be made with greater ease and accuracy.

Fig. 1.

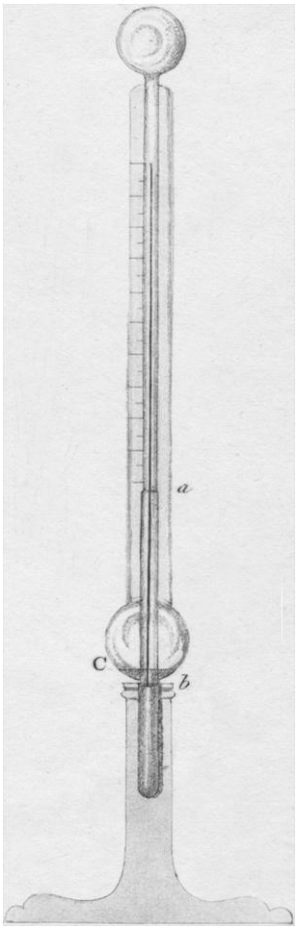


Fig. 2.

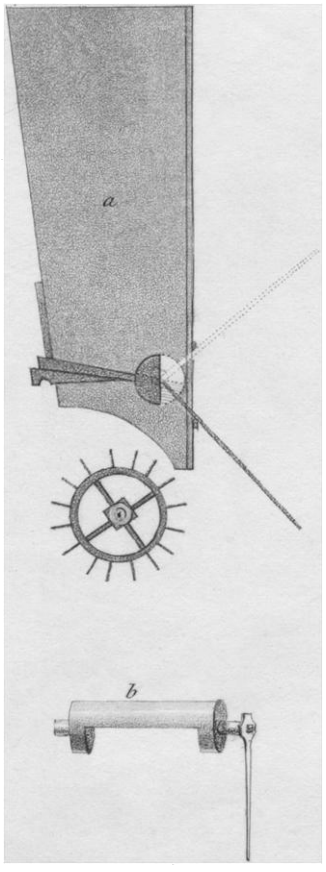


Fig. 3.

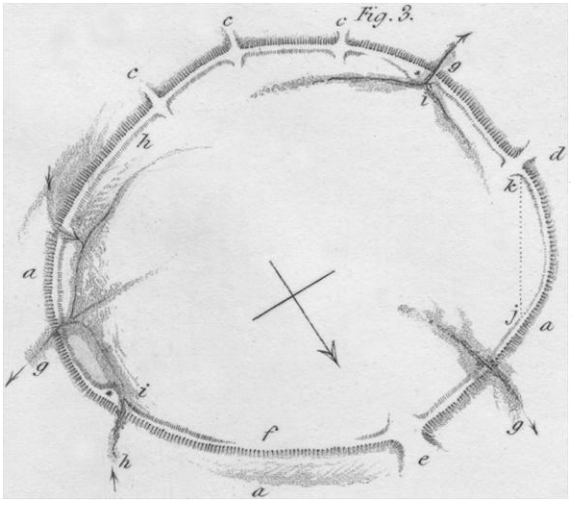
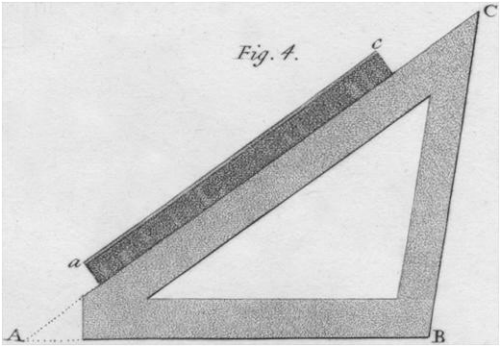


Fig. 4.



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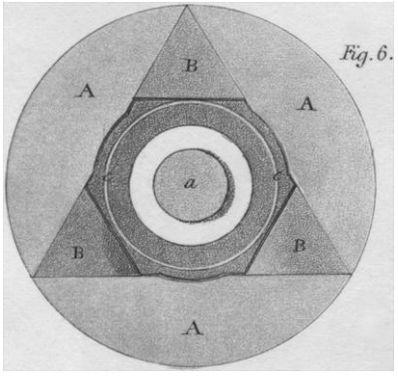
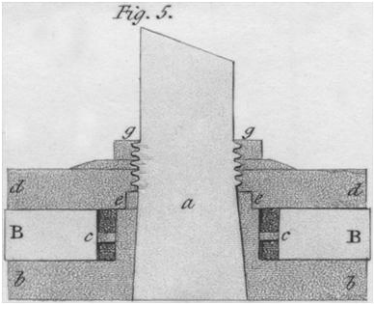


Fig. 5.



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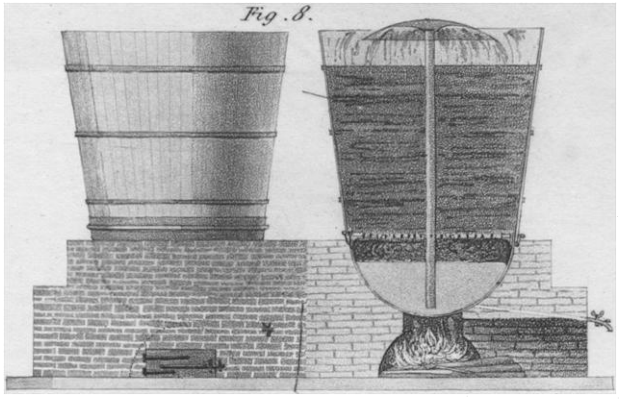

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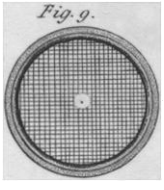

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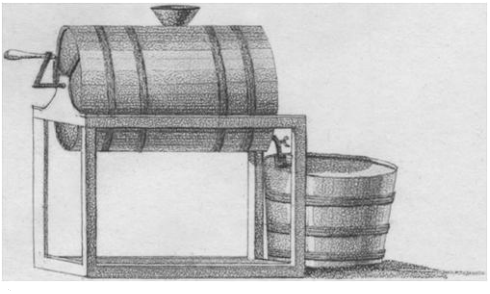

Engd. by J. Hill.